CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Sewage sludge is the semi-solid material, also referred as biosolids, is the byproduct of sewerage treatment plant. It contains mineral, organic and biological impurities in soluble, insoluble and colloidal form. According to *Eleventh Malaysia Plan* (n.d.), 2016 – 2020, is intended to be the foundation for Malaysia to embark on the new frontier of development. The population in Malaysia is estimated to reach 32.4 million in 2020 and 36 million by 2030. As the population is expected to grow drastically in near future, for sure, the generation of the sewerage sludge will be increase as well. An estimation of 7 million cubic metres of sewage sludge will be produced in the year of 2020 annually and it is recorded by Indah Water Konsortium Sdn Bhd (2010). It is estimates that approximately 1.7 million tonnes of incinerated sewerage sludge produced annually world-wide and is likely to increase in the future. The best way to recycle the nutrients and the organic matters that contained in sludge is through the utilization of land (Sánchez-Monedero et al., 2004).

If the sewage sludge is free from any toxic substances, it will be a great fertilizer for land application. According to the Environment Guidance for Your Business, if the farmers who want to apply the sewage sludge the agricultural land, then they must make sure that the sludge being spread fulfilled the specified requirement of the Sludge Regulations. There are four different types of disposal make up a distinctive offer to treat the total volume of sewage sludge. In five of the EU Member States — Portugal, Ireland, the United Kingdom, Luxembourg and Spain (information refer to 2012, except for Ireland where the latest information available is for 2013), around 75% of the total

was used as fertilizer for agricultural. In contrast, 66% of sewage sludge was composted in Lithuania and Finland (both 2012 data), while around 86.6 % of the total in Estonia. By disposing the sewage sludge through alternative types of disposal measures such as incineration and landfill, it can effectively eliminate or reduce the spread of pollutants on agricultural or gardening land. While the Netherlands, Belgium, Germany, Slovenia and Austria (as well as Switzerland) reported incineration as their priority to dispose the sewage sludge. In addition, controlled landfills were practiced as the principal type of treatment in Malta (where it was the sole type of treatment), Romania and Italy, as well as Bosnia and Herzegovina (Eurostat, 2012).

According to Eurostat (2013), we can observe that some of the countries prioritize the sewage sludge as one of the fertilizer in agricultural. Most of the sewerage sludge are incinerated to reduce minimize its volume prior to landfilling or fertilizer in the agriculture sector. Unfortunately, the studies had shown that the sewage sludge contain quite number of different type of toxins that might detrimental to human's health. Recent research has found the presence of heavy metals in Incinerated Sewage Sludge Ash (ISSA). Thus ISSA is no longer suitable for landfilling and as fertilizer for edible crops. The survey had discovered that there are poor bioavailability of phosphorus in the sewage sludge and that more than 50% of the ashes cannot be used as fertilizers due to high heavy metal content (Herzel et al., 2015). Furthermore, due to the physical-chemical processes that are involved in activated wastewater sludge treatment, sludge tends to accumulate heavy metals existing in the wastewater. The heavy metals in sewage sludge included zinc (Zn), copper (Cu), nickel (Ni), cadmium (Cd), lead (Pb), mercury (Hg) and chromium (Cr) are principal elements restricting the use of sludge for agricultural purposes (Hsiau & Lo, 1998). Table 1.1 show the typical metal content in wastewater sludge.

Table 1.1: Typical metal content in wastewater sludge

Metal	Dry sludge (mg/kg)	
	Range	**Median**
Arsenic	1.1-230	10
Cadmium	1-3.410	10
Chromium	10-990.000	500
Cobalt	11.3-2490	30
Copper	84-17.000	800
Iron	1000-154.000	17.000
Lead	13-26.000	500
Manganese	32-9870	260
Mercury	0.6-56	6
Molybdenum	0.1-214	4
Nickel	2-5300	80
Selenium	1.7-17.2	5
Tin	2.6-329	14
Zinc	101-49.000	1700

Source: Hsiau & Lo (1998)

Concerns had been increased towards the exposure of emerging pollutants such as metals, organic contaminants and pathogenic bacteria in sewage sludge as it might threaten human's health as crops had been cultivated in sewage or compost-amended soils (Zuloaga et al., 2012). As the sewage sludge contains all this components after incineration, ISSA becomes a refined pozzolan that can trigger the pozzolanic reaction in the cement based reaction. Tantawy et al., (2012) has proved that the pozzolanic activity is the reaction that can enhance the strength development of the cement based material at the late stage of curing. In addition, the size of the particle of SSA becomes relatively small after going through incineration process. As the particle size become small, it can easily fill up the voids and pores in the cement based materials and surely, the porosity of the cement based material will be reduced. It clearly showed that the ISSA have potential to be used as part of construction material.

An eggshell is the hard, outer covering of the egg. The eggshell itself is rich in calcium carbonate, $CaCO_3$, which corresponds to about 94% of the shell (Murakami et al., 2007). Eggshell is known to have potential in mixing with the cement based material to improve the properties and strength. Tsai et al., (2007) discussed that the eggshell is traditionally useless and is disposing through landfill and Most of the eggshell waste is